when the results of scientific investigations are used as a medium for humor, their true objects are, of course, entirely lost sight of, and science is belittled; and, as humor appeals to the greater number the lower its order, it is clear that the kind of humor we are dealing with must appeal to large numbers of those who are in special need of enlightenment.

Scientific investigations are not proper subjects for the display of wit. The object of these investigations is to discover the foundation of all things, — the truth. Let a man once grasp that idea, let him become imbued with it, let him go through the process of intellectual regeneration necessary to enable him fully to appreciate it, and it will henceforth be impossible for him to touch upon the subject of investigation without experiencing feelings which are totally incompatible with ordinary wit. This is the right attitude towards scientific matters. It cannot be brought about all at once, but the day when it shall be the general attitude can be hastened by those who mould public opinion.

Gentlemen of the press, it is your duty to do all in your power to encourage scientific work, and to give the people right ideas concerning it. We cannot expect this from all. There are many among you whose highest ambition it is to secure and construct 'readable' articles at any sacrifice of principle. But surely it is not too much to expect of those who evidently recognize the importance of higher things.

THE DRY- AND WET-BULB HYGROMETER.[1]

It is not my purpose at present to discuss the theories which underlie hygrometric observations, but rather to ascertain if it is possible to obtain uniform and trustworthy results from the simple observation of this instrument. There has been much discussion of late upon this subject, and grave doubts are continually being thrown upon its accuracy.

It is proposed to ascertain, first, the best method of conducting observations, and, second, the accuracy of the results when compared with a fixed standard. The following is a brief statement of the principles upon which the action of this instrument is based: —

"The evaporation of a liquid involves the conversion of sensible into latent heat; and the supply of heat must be drawn from the liquid or from surrounding objects. At some point the amounts of heat subtracted and communicated will be equal, and an invariable temperature of evaporation will result, depending upon the amount of moisture present."

From this invariable temperature we may be able, by suitable formulae, to obtain the hygrometric state of the atmosphere.

It would seem as though a thermometer-bulb, from which moisture is continuously evaporated, ought to give this needed temperature; yet every one who has had occasion to make such observations has encountered great difficulties, and has become satisfied, that as commonly made, though the readings are of the simplest character, yet the results are frequently entirely inaccurate. This is partially shown by an examination of the various directions that have been published from time to time. Regnault, writing in 1845, says, "I prefer thermometers with cylindrical bulbs as more susceptible to the variations of temperature, and because, for the same mass of mercury, they present a much greater surface to the air. The manner of moistening, I find, makes no difference so long as there is an abundance of liquid. If a drop falls from time to time from the extremity of the bulb, I have still observed no sensible difference. The longer or shorter course which the water runs on the cotton wick exercised no perceptible influence." Other authorities may be quoted as follows: —

Bulbs of both thermometers should project an inch and a half to two inches below the scales; and all objects, metallic or otherwise, which can affect the temperature, should be removed.[1]

All authorities mention the necessity of using rain or distilled water, of frequent cleansing of the muslin, and of changing it at intervals of from half a month to three months. The greatest difference of opinion, however, is in relation to observations below freezing, 'under which circumstances,' says Mr. Scott in his

[1] Read before the Philosophical society of Washington, D.C., May 5, 1883, at its 235th meeting.

[1] This is an important matter. I have seen several illustrations of this instrument, showing the scales extending below the thermometer-bulb; and many otherwise accurate thermometers are made with a metallic scale prolonged so as to afford protection to the bulb. In using such a thermometer as a wet bulb, I have found, with the scale, a mean temperature 1.2° higher than without it; the air was still; there was an abundance of moisture, and over 10° difference between the dry and the wet. This is due partly to the heat radiated from so near an approach of metal at least 10° hotter than the wet bulb, and partly to the arrest of evaporation by the scale.

book just issued, 'the dry- and wet-bulb hygrometer fails.' Some of the directions are as follows: —

Wet the muslin with a camel's-hair brush or a sponge fifteen minutes before the observation. The film of ice should be as thin as possible. Remove the muslin, and wet with brush. Wet, by raising a cup and immersing the bulb for a moment, twenty minutes before the reading. Wet some time, say an hour, before the observation. Wet immediately after a reading, and it will be ready for the next. One authority suggests, that, if the air is still, it is well to increase the evaporation by a fan. Regnault has established that no appreciable error is introduced by an air-current as high as five or six metres per second (metres per second may be readily converted into miles per hour by using the factor 2.24). The Italian government, some years ago, introduced an induced air-current in their hygrometric observations.

Relative humidity at 7 A.M., February, 1883.
Deduced from observations of the dry- and wet-bulb hygrometer

	(1) Kendall Green.	(2) Fort Myer.	(3) West Washington.	(4) Naval Observatory.	Residuals. (1)—(2)	(1)—(3)	(1)—(4)
Feb. 1	76	77	76	100	— 1	0	—24
" 2	75	88	80	100	—13	— 5	—25
" 3	87	89	89	91	— 2	— 2	— 4
" 4	88	78	86	96	10	2	— 8
" 5	95	100	94	94	— 5	1	1
" 6	72	61	80	88	11	— 8	—16
" 7	98	100	89	100	— 2	9	— 2
" 8	83	68	76	94	15	7	—11
" 9	88	77	88	93	11	0	— 5
" 10	75	64	70	82	11	5	— 7
" 11	80	100	83	100	—20	— 3	—20
" 12	64	72	53	73	— 8	11	— 9
" 13	88	88	82	82	0	6	6
" 14	85	100	88	94	—15	— 3	— 9
" 15	100	100	89	96	0	11	4
" 16	98	100	100	100	— 2	— 2	— 2
" 17	90	100	100	100	—10	—10	—10
" 18	84	100	100	87	—16	—16	— 3
" 19	80	73	73	94	7	7	—14
" 20	84	83	82	100	1	2	—16
" 21	74	53	62	61	21	12	13
" 22	87	77	78	88	10	9	— 1
" 23	76	60	72	89	16	4	—13
" 24	83	73	69	94	10	14	—11
" 25	78	79	100	100	— 1	—22	—22
" 26	80	60	73	68	20	7	12
" 27	84	70	52	87	14	32	— 3
" 28	81	79	68	100	2	13	—19
Mean for Feb. .	83	81	80	91	2	3	— 8
		Iowa Circle					
" " March .	64	72	68	85	— 7	— 4	—21

As an illustration of the varying results obtained by the common method of observing this hygrometer, I have given the preceding table, showing the relative humidity at four stations in Washington. 1. Kendall Green. This station is situated about a mile and a half north-east of the capitol, and has an exposure of thermometers some fifty feet above ground. 2. Fort Myer, situated about three miles west, and has an exposure about forty feet above ground. 3. West Washington, situated about three miles west, with an exposure about thirty feet above ground. 4. Naval observatory, about two miles west, with an exposure four feet above ground.

This table shows an extreme difference of 35% for a single observation. The very high per cent found at the observatory is due in part to the exposure being so near the ground. This suggests an interesting subject for investigation. It has been determined by experiment in Europe, that, with proper precautions, the actual air-temperature is the same, whether measured at five or a hundred feet above ground. Now, if it be found that the lower exposure gives higher percentage of moisture, due to the settling of fog-banks or strata of damp air, it becomes a matter of the highest importance to ascertain the differences in moisture in different strata, and to settle upon some uniform height for all hygrometric observations.

During the past winter, I have made a large number of readings, hoping to remove some of the recognized difficulties in this class of observations. The exposure of the hygrometers was from a north window forty feet above ground. Great care was taken to exclude all heated currents. The temperatures were from 10° to 50° F.

As an example of these observations, I append a table exhibiting two sets of readings taken on Feb. 13, 1883. The air was perfectly still, and the pressure was 30.40″. The readings were made at intervals, as shown in the table, without disturbing the instrument.

Readings of dry- and wet-bulb hygrometer on Feb. 13, 1883.

First set. Time.	Temperature. Dry.	Wet.	Second set. Time.	Temperature. Dry.	Wet.
4.29 A.M.	-	Wetted.	5.37 A.M.	-	Wetted.
4.37 "	31.8°	32.1°	5.47 "	31.5°	32.1°
4 50 "	31.3	31.4	6.4 "	31.8	32.0
5.4 "	31.1	30 3	6.17 "	30.9	30.9
5.14 "	31 0	30.0	6 28 "	31.0	30.4
5.19 "	31.0	29.8	6.36 "	30.9	30.1
5.26 "	31.1	29.4	6 54 "	30.6	28.4
5.29 "	31.0	29.1	7.0 "	31.0	29.4
5.32 "	31.0	29.4			

As the temperature of the wet bulb was rising at the last observation in each case, it is

evident that the ice had entirely evaporated. At the 5.29 reading, Regnault's formula gives a dew-point of 25.3°, and the condensing hygrometer gave at the same time a dew-point 20.4°. In the second set at 6.54, *seventy-seven minutes after wetting*, the dew-points were 24.0° and 19.7° respectively. It will be seen that the length of time required in the last set (seventy-seven minutes) is entirely too great for good results, as in this time the temperature may change several degrees; and there is so great uncertainty in the length of time required, that, to obtain a good result, it would be essential to wet the bulb an hour and a quarter or an hour and a half before the time, and then note the temperature from time to time in order to catch it when it has ceased falling. The above conditions of observation are ordinarily impracticable, and, besides, the final results, showing dew-points about 4.5° higher than the condensing hygrometer, are entirely unsatisfactory.

I have investigated the effect of an induced air-current as a means of effectually removing these and other objections. Experiments were tried with fans, common hand-bellows, and a Casella whirling apparatus. All of these trials showed, that, with a velocity of the air-current ranging from 1.5 to 5 metres per second, the readings of the dry- and wet-bulb hygrometer are nearly identical.

The length of time required to bring down the wet-bulb temperature rarely exceeds two minutes: in only one extreme case did it require thirteen minutes. If it be objected that any form of motor for producing an air-current must necessarily compress the air, and by heating it vitiate the results, it may be said that the compression need be very slight. Experiment shows that the induced current produces, if any thing, a lower temperature, at least in the winter season; and, since the air-current reaches both thermometers, the differential results will not be affected.

The most satisfactory showing of experiments with an induced air-current, however, is that uniform and accurate results may always be obtained at temperatures as low as 10° (which is the limit that has occurred the past winter), as determined by comparison with a Regnault's condensing hygrometer; and undoubtedly the same would be found at temperatures even below 0° F. The simplest motor for the induced current for any exposure, except from a window, is a common fan; another convenient form, and one by far the easier to use, is the hand-bellows. For a window-shelter, the latter can be readily rigged with a pulley and string so as to be operated from within; and this is the form used by myself. I have mentioned above the whirling apparatus of Casella. This, though giving good results, is much more complicated and expensive, and is, moreover, unsuited to a window-shelter. There are manifold other forms of motors, but it is doubtful if they would be any better than those already described.

I have carefully measured the induced air-currents with a Casella air-meter, and have found that a fan making a hundred strokes a minute in one direction, and placed within three or four inches of the meter, gives a velocity of 1.5 metres per second; that a bellows of a litre capacity, making fifty strokes to the minute, at a distance of six inches, gave a velocity of 2 metres per second, while at twelve inches it gave 1.8 metres per second; and that the whirling apparatus easily revolved the thermometers at the rate of 5 metres per second.

The expense of a fan would be nominal; a strong hand-bellows, with all necessary appliances, ought not to cost more than $2.50.

In order to exhibit the advantage to be gained by ventilating this hygrometer, I give the following table, containing observations with it, and, for comparison, those with the condensing hygrometer, as made at seven A.M. during twenty-nine days of March, 1883.

From this table we see that columns 6 and 7, which contain dew-points computed from the ventilated hygrometer, and determined by Regnault's condensing hygrometer, respectively, show a close agreement; the difference of 2.1° between the means being due in part to the formula of reduction used with the dry- and wet-bulb instrument.

Columns 8 and 9 show a mean monthly difference in the relative humidity, by the unventilated and ventilated bulbs, of 10%, and an extreme difference of 26%, for a single observation, in favor of the ventilated.

Since conducting the above investigation, my attention has been called to similar work done by Mr. Sworykin in Russia. The means of fifteen observations, as given by him, are as follows: mean air-temperature, 21.5° F.; relative humidity, unventilated 59%, ventilated 55%; mean velocity of wind during the observations, 11 miles per hour.

The formulae of reduction used in this paper are those determined by Regnault. He himself declared these unsatisfactory; but they are the best we have, and certainly, as my experiments have shown, very superior to the factors of Glaisher. Many very carefully conducted observations at temperatures below 0° F., and at

Hygrometric observations at Iowa Circle, Washington, at 7 A.M., during March, 1883.

	1	2	3	4	5	6	7	8	9	10	11
	Unventilated.		Ventilated.		Dew-point.			Relative humidity.			Velocity.
	Dry.	Wet.	Dry.	Wet.	Unvent'l'd.	Ventilated.	Regnault condensing apparatus.	Un-v'nt'd.	Venti-lated.	8–9	Miles per hour.
								%	%	%	
March 1 .	31.0°	29.1°	30.6°	28.1°	25.3°	23.1°	24.5°	79	73	6	0
" 2 .	45.8	42.3	45.6	41.0	37.3	33.8	34.3	72	64	8	1
" 3 .	37.5	32.5	37.4	32.0	22.0	20.6	18.3	52	49	3	8
" 4 .	31.0	29.3	30.6	28.0	25.9	22.8	17.5	85	71	14	6
" 5 .	19.1	17.0	19.0	16.4	10.5	7.4	2.4	68	59	9	4
" 6 .	31.2	30.3	31.0	29.4	28.5	26.2	25.6	89	82	7	5
" 7 .	40.1	35.2	40.0	35.0	26.4	26.0	23.0	58	57	1	11
" 8 .	16 4	15.0	16.1	14.1	10.4	7.2	1.9	76	67	9	2
" 9 .	21.0	21.0	20.7	19.0	21.0	13.9	15.0	100	74	26	0
" 11 .	34.7	31.1	35.0	30.2	23.8	20.8	22.2	64	55	9	2
" 12 .	29.9	26.1	29.6	25.1	17.3	14.7	11.1	57	51	6	4
" 13 .	35.5	31.9	34.7	30.7	25.1	23.4	19.9	65	63	2	0
" 14 .	40 5	37.1	40.5	36.7	31.3	30.1	27.4	70	66	4	0
" 15 .	51.5	47.9	50.3	46.2	43.7	41.0	41.7	75	71	4	6
" 16 .	23.7	20.4	23.3	19.4	10.9	7.1	4.4	57	48	9	6
" 17 .	31.6	30.9	32.3	29.7	29.5	24.5	17.8	92	71	21	3
" 18 .	37.7	34.9	37.5	33.8	30.6	26.7	27.2	75	64	11	3
" 19 .	46.8	42.0	46.8	40.7	35.0	31.3	31.1	64	55	9	2
" 20 .	27.4	24.4	28.1	24.0	17.4	13.7	10.7	64	53	11	12
" 21 .	22.9	20.8	22.9	19.0	15.5	6.4	0.2	72	47	25	8
" 22 .	23.4	21.6	22.9	20.0	17.2	12.3	7.1	75	62	13	4
" 23 .	33.0	31.0	32.4	29.8	27.0	24.6	22 9	78	72	6	8
" 24 .	24.2	22 0	24.3	21.1	17.2	12.4	10.0	73	58	15	8
" 25 .	30.8	29.2	30.2	28.0	26.0	23.6	22.5	82	75	7	1
" 26 .	36.8	32.9	37.0	31.7	25.6	20.4	21.1	63	50	13	4
" 27 .	39.7	34.7	39.7	34.4	25.4	24.4	25.3	56	53	3	8
" 28 .	33.2	28.1	33.4	27.9	17.0	15.8	13.8	49	46	3	9
" 29 .	35.2	34.9	35.2	33.8	34.3	31.0	32.7	96	84	12	3
" 31 .	36.2	35.1	36.7	34.0	32.9	29.0	30.4	88	73	15	4
Mean . .	32.7	30.0	32.5	28.9	24.5	21.5	19.4	72.2	62.5	9.7	4.6

elevated stations, will be needed before these formulae can be improved.

The following directions may be given as essential to the satisfactory working of the dry- and wet-bulb hygrometer: —

In order to obtain accurate results, an induced air-current from 1.5 to 5 metres per second (3.4 to 11.2 miles per hour) is essential. This is needed even with moderately high wind; as experiment has shown, that, in a double-louvred shelter, with a wind of 12 miles per hour blowing directly through it, a velocity of only 1 to 1.5 miles per hour was recorded in the most favorable spot.

The thermometers should be preferably cylindrical, with the bulb removed an inch or more from the scale; and no metallic substance should be permitted near the wet bulb. The dry thermometer should be kept clean, as dust and grit would cause a deposition of moisture in foggy weather.

The muslin should be fine, and tied smoothly over the bulb. It needs cleaning as often as it appears to be turning yellow. If dust settles upon it, it can be easily cleaned with water.

Clean rain or melted-snow water should be used for wetting. A strip of cotton three-eighths of an inch wide, or a wick, will serve to make connection between the muslin and the reservoir in warm weather. If the air is very dry, this strip will cease acting; and in such case the bulb may be immersed for a moment. It will be found, that if the reservoir is kept full, and the angle of the cotton is not too great, the latter difficulty will seldom be encountered.

If any moisture is seen on the dry thermometer, it should invariably be wiped off.

If the air-temperature approaches freezing, the reservoir should be removed; though the wick may be left, its end being carried up and fastened to the frame in such a way as to permit of immersing the bulb. The water in the reservoir should be kept in the open air until a film of ice forms upon it, the intention being to keep it as near freezing as possible. The bulb should be repeatedly wet by immersion till a coating is formed, the thickness of which should depend on the difference between the dry and wet bulbs and the velocity of the air-motion; i.e., the greater the difference and the velocity, the thicker the coating. There is no difficulty with an induced air-current in obtaining accurate results with a coating 1 mm. in thickness.

If ice is found on the bulb with an air-temperature at or above freezing, it may be evaporated by the air-current, or melted off with water. The former method is preferable if the wet-bulb temperature is below freezing. If, on immersing, a drop is found at the bottom of the bulb, it can be easily removed before it freezes by touching with the edge of the reservoir.

With these precautions, an accurate determination of the moisture in the air may be made; and this must necessarily add to the value of hygrometric observations, which are so important in the study of the progress and development of storms. H. A. HAZEN.

A STUDY OF THE HUMAN TEMPORAL BONE.[1]—III.

THE temporal bone at birth consists of three osseous pieces suturally connected and partially anchylosed, but readily separable. The pieces are named the *squamosal*, *petrosal*, and *tympanal bones*. In some animals they remain permanently distinct, and in others are variously anchylosed. The squamosal and petrosal correspond in the main with the squamous and petrous portions of the temporal as usually described; but the so-called mastoid portion is derived from both the former. The squamosal contributes about one-third to the mastoidea, while the petrosal contributes the remainder.

The *squamosal* is a nearly circular upright plate which joins the petrosal at the *petro-squamosal suture*. This appears internally as a fissure, extending from the notch at the lower border of the squamosal, in front, to the notch at its border behind. Externally it descends from the latter notch to a position just behind the tympanal.

The mastoid portion of the squamosal is proportionately larger than later, and its auditory plate is less distinctly differentiated from the general plane of the bone. Internally it is defined by a shelf on which rests the contiguous border of the tegmen of the petrosal. Below the shelf, the auditory plate exhibits the smooth surface of the scute, which forms the outer boundary of the attic of the tympanum. The cellular portion above and behind forms the outer boundary of the mastoid antrum. The articular surface for the lower jaw is a shallow concavity, with scarcely a distinction of glenoid fossa and articular eminence; and it deviates relatively little from the general plane of the squamosal.

The *petrosal* obscurely displays the labyrinth, already of mature size and bounded by compact walls, embedded in more spongy substance, from which it may be readily excavated. The superior semicircular canal is especially conspicuous, and includes a large recess, which is subsequently obliterated. The tegmen appears as a distinct triangular plate projecting from the petrosal and overlapping the shelf of the squamosal. The tympanic cavity with its attic and the mastoid antrum are well produced, and are of nearly mature size.

The mastoid portion of the petrosal extends behind that of the squamosal, and is commonly partially anchylosed with it. Its upper extremity is notched to a variable degree; and its lower part exhibits a comparatively slight eminence, premonitory of the future conspicuous mastoid process.

The *tympanal*[1] is a horseshoe-like bone, with its ends anchylosed to the auditory plate of the squamosal. From this it slants downward and inward, and is suturally connected along its posterior and lower border with the petrosal. Its inner margin is grooved for the insertion of the tympanic membrane.

In the development of the temporal bone, the squamosal and tympanal are produced from fibro-connective tissue, and the petrosal and styloid process from cartilage. Ossification commences in the squamosal about the close of the second month of embryonic life; a centre appearing at its lower part, and extending upward in the squamous and mastoid portions, and outward in the zygomatic process. The following month, a centre appears in the lower part of the tympanal, and grows into a slender ring, incomplete above. Ossification commences in the petrosal near the middle period of foetal life. Two centres appear, and extend in the walls of the labyrinth. These centres have been appropriately named by Professor Huxley the *prootic* and *opisthotic*. They quickly coalesce to form the labyrinth, by the subsequent continued growth of which the pyramidal and mastoid portions of the petrosal are developed.

The prootic produces all that portion of the petrosal seen within the cranial cavity, except that which is contiguous to, and forms, the jugular fossa. It gives rise to the upper part of the cochlea, including its base and cupola; to the internal auditory meatus, the upper part of the facial canal and its hiatus, the upper part of the oval window, the superior and external semicircular canals, the upper arm of the posterior semicircular canal, and the tympanic tegmen.

The opisthotic produces all the petrosal seen

[1] Concluded from No. 17.

[1] Auditory process, annulus tympanicus.